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Food consumption and weight response of elk (Cervus canadensis nelsoni) under winter conditions

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THE FOOD CONSUMPTION AND WEIGHT RESPONSE OF ELK (*Cervus canadensis, nelsoni*) UNDER WINTER CONDITIONS

by

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[1]The Montana State Fish and Game Department, Montana State University, the U. S. Fish and Wildlife Service, and the Wildlife Management Institute, cooperating

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES AND PLATES

INTRODUCTION

Proper management of big game requires the establishment of a balance between population numbers and food supply. This balance is necessary to achieve maximum health and productivity of animals as well as full forage production, soil stabilization, and watershed value of the game range. Big game population and food supply are frequently out of balance as evidenced by damage to adjacent agricultural areas and overuse or elimination of some plants from their range. In some cases the equilibrium may be disturbed by an overabundance of one big game animal to the detriment of another. To establish a balance, we need to know not only the amount of available forage produced per unit of range, but also the forage needs of each big game species present.

Food habits of wild ruminants are not sufficiently specialized to prevent competition. The elk is the most versatile of them all and is most likely to cause harmful rivalry (Murie, 1951). By reason of its size and number in western Montana, its total forage and range requirement is very large. Before the elk population can be brought into balance with its food supply, the food requirements of the elk must be known. Knowledge of the food requirement of elk is also necessary in order to measure their degree of competition with other wild ruminants. Experimental pen feeding can provide food requirement information. The value of various foods presented to the animals is roughly expressed in animal condition and weight changes as responses to diet and to a lesser extent by the difference in amounts of food consumed.

The purpose of this study was to determine the response of Rocky Mountain elk (Cervus canadensis, Nelsoni) when fed the following three diets: meadow hay, cured native bunch grass, and native browse plants. Effects were determined by animal condition and weight changes. A significant aspect was to determine the effects of weather upon weight trends and food consumption of elk.

The two diets of native bunch grass and native browse plants were chosen as most significant in the winter diet of elk in Montana. Meadow hay was used as a basis of comparison and to evaluate hay in artificial feeding.

REVIEW OF LITERATURE

The determination of the food requirement of animals by feeding trial is a conventional method. The true value of any livestock food is best determined by actual feeding experiments with the particular class of animal under controlled conditions. Chemical analysis does not account for all of the factors determining the value of a food. Animal husbandry investigators have fully appreciated this fact as evidenced by many hundreds of experiments with domestic livestock.

Several investigators have conducted studies with both mule deer and white-tailed deer. Nichol (1938) carried on a three year study in Arizona to determine the feed requirement for growth and maintenance of deer expressed in pounds of forage per hundredweight of deer. It was found that the average consumption of a mixed herd of mule deer (Odocoileus hemionus macrotis) and Arizona whitetails (Odocoileus couesi) was 2.35 pounds per hundredweight.

Doman and Rasmussen (1944) reported feeding mule deer several different rations of alfalfa hay combined with various supplements, as well as other trials with browse species. For maintenance they recommended 3.0 pounds of air dry forage per hundredweight of deer and 4.0 pounds per day for the average deer.

Smith (1950) reported the consumption of browse species by mule deer in a preference study to be 2.7 and 2.6 pounds per day for a 107 pound and a 106 pound mule deer. Weight was not maintained, however.

Davenport (1939) found the average daily total consumption to be

2.94 pounds for fawns, 1.91 pounds for does, and 1.85 pounds for bucks expressed in pounds per hundredweight of northern white-tailed deer (Odocoileus virginianus).

Moreland (1951) found black-tailed deer (Odocoileus columbianus columbianus) to consume 2.85 pounds per hundredweight per day on an unrestricted natural diet.

Findings of various workers differ considerably, as evidenced by the examples listed above. Variation in part may be due to the type of forage, animal variation and climatic influence. Findings based on unrestricted natural diets average between 2.5 and 3.0 pounds per hundredweight of deer.

Feeding studies with elk are limited. Olson (1945) reported one mature elk fed at the Utah State Fish and Game Farm consumed 10 pounds of hay and 5 pounds of grain per day or an equivalent of 17.5 pounds of hay. He also stated that a group of seven elk including one calf, two yearlings, two cows and two bulls were fed a ration of 11 pounds of hay per animal per day. Olsen concluded that adult elk need 16 pounds of hay per day.

Blunt (1951) recorded the consumption of alfalfa hay be elk calves by using "creeper corrals" accessible to calves but not adult elk. The calves consumed an average of 3.6 pounds per animal per night. He stated, however, that the number of animals using the corrals was uncertain.

Murie (1951) lists the daily ration fed per elk in several zoological parks as follows:

National Zoological Park, Washington, D. C. - 10 pounds mixed hay, 4 quarts oats and corn, and 1 pint bran.

New York Zoological Park - 7 pounds clover hay, 6 quarts plus crushed oats, some vegetables (more grain in winter).

Philadelphia Zoological Garden - 10-15 pounds mixed hay, 3 quarts cracked corn, crushed oats, and bran.

Rutledge (1938) reported adult elk required 16 pounds of air dry forage per day. His data were obtained from zoos.

Murie (1951) reports a study made on the National Elk Refuge in Wyoming in the winter of 1940-1941 to determine the food requirements per day, per individual, and per hundredweight, over a period of 43 days. In one pen 29 elk calves were placed, and in another pen, 25 adults (7 bulls and 18 cows). The animals were weighed at the beginning of the experiment on February 5th and at the conclusion on March 9th. The hay given them was weighed each day. The amount of food left by the elk was evidently not weighed out. During the same period, a neighboring rancher cooperated in this study by weighing three Hereford cows and one steer and feeding them weighed hay from the same haystack. The following average amounts consumed per day were:

Elk calves	7.8 pounds each	or 3.11 pounds per cwt.
Adult elk	12.5 pounds each	or 2.7 pounds per cwt.
Adult cattle	31 pounds each	or 3.6 pounds per cwt.
Elk all ages	9.8 pounds each	or 2.7 pounds per cwt.

The animals were all given as much hay as they would eat. The cattle gained in weight while the elk not only lost weight but progressively ate less. Murie commented that the decrease in consumption may have been caused by increasingly warmer weather toward the conclusion of the experiment.

There is some disagreement between these studies as to the amount

necessary for maintenance. Considerable difference could be caused, however, by weather and other factors.

No other reports could be discovered describing actual feeding of elk for the purpose of determining maintenance requirements or other similar information. Amounts of daily consumption have been estimated by other methods. From data gathered on a grass clipping plot on the Lewis and Clark National Forest it was estimated that elk consume 21 pounds of grass per animal per day, from December through March (Gaffney, 1941).

On the National Elk Refuge in Wyoming hay feeding has been conducted for many years. The gross tonnage of baled hay fed over a known period of time compared with the number of animals on the feed grounds indicates a daily consumption of 7 to 10 pounds per animal (Murie, 1951).

Murie (1951) reports an examination of 139 elk paunches by Assistant Chief Ranger Maynard Barrows of Yellowstone National Park. The dried contents averaged as follows:

Bulls	13.753 lb.
Cows	9.498 lb.
Calves	7.512 lb.

From these data, Murie concluded that for the period represented by the stomach content, adult elk require about 11.5 pounds and calves 8 or 9 months old about 7.5 pounds per day.

These figures are expressed as air dry weight of paunch content. Paunch weights of adult elk, not air dry, are much higher. Schwartz and Mitchell (1945) report wet paunch weights of freshly killed elk to be 60 to 98 pounds. West (1941) refers to a paunch of an adult cow as being 87 pounds wet weight. The dried contents were 12.8 pounds or 15 per cent of the wet weight.

Forage consumption equivalents are generally expressions of the degree of competition between animal species as well as a comparison of amounts consumed by each species. Some authors quote direct comparisons. Murie (1951) states the ratio was roughly 2.5 elk to 1 head of cattle for the study at the National Elk Refuge when cattle and elk were experimentally fed on hay from the same hay shed. Stoddard and Smith (1943) quote Rasmussen, et al. (1941) as giving a rating of one elk to 4.26 sheep and 1.88 elk to 1 cow. These figures were based upon herd run weights at the end of the grazing season. Pickford and Reid (1945) defined 1 cow as equal to 1.25 elk. Rush (1930) quotes a figure of 1.33 elk per head of cattle.

In evaluating the forage requirement for elk, we again find as much variation as there was with deer. The average consumption for adult elk seems to be about 12-14 pounds per day or 2.5 to 3.0 pounds per hundredweight for adult animals. The report by Murie (1951) was the only reported study found that has been carried out under controlled conditions with the animals and the food being weighed. This study was conducted with grass hay as the single item of diet and with grouped animals.

As previously stated, the findings based on unrestricted natural diets for deer averaged between 2.5 and 3.0 pounds per hundredweight of adult deer and 2.5 and 3.0 pounds per hundredweight for adult elk. In comparing these with maintenance studies with domestic ruminants, it was found by Guilbert and Rochford (1940) that cattle consumed about 3.0 pounds of dry matter per 100 pounds live weight daily, varying from 2.0 to 3.25 pounds. Morrison (1936) states that for wintering pregnant ewes, a ration of 2.0 to 2.3 pounds of dry matter per hundred pounds of body weight is required.

Maintenance requirements for domestic ruminants are often based on chemical composition and digestible nutrients. Much of their natural forage is of unknown or variable nutritive value. Very few digestion trials have been run with big game, and these generally for purposes other than determination of a maintenance diet. Forbes (1941) compared the nutritive value of feeds for deer, and Smith (1950a) reported a digestion trial on mule deer with sagebrush, to determine its value to deer.

Animal weight is accepted as a standard method of defining maintenance requirement (Stoddard and Smith, 1943). Body surface is believed to be a more direct index to food requirement but it is more difficult to determine (Brody, 1934). Experience in feed lots with cattle show that weight is a sufficiently reliable index (Stoddard and Smith, 1943).

Maintenance of weight is the basic criterion for defining a maintenance ration. Wintering of game animals in colder climates may, however, be accompanied by a normal loss of weight during this season. Murie (1951) states that elk usually lose weight during the winter. The animals he refers to, used in feeding trials in Jackson Hole, also lost weight. Of the feeding trials with deer, those in southern climates maintained weight. In northern climates many lost weight unless fed natural forage plus a supplementary domestic food. Trippensee (1948) states that loss of weight during the winter is probably characteristic of most deer.

Some work has been done to determine the amount of weight lost before death occurs. Feeney (1946) considered a thirty per cent weight loss to be fatal in deer. He considered a twenty per cent weight loss of adults and a fifteen per cent weight loss of fawns to be "allowable"

and based their diet maintenance success or failure on these figures. Morrison (1936) states . . . "horses and ruminants will die when their weight has been reduced twenty to twenty-five per cent".

It is generally conceded that the winter ranges are the most critical. Murie (1951) states, "It has become a truism that the winter range is the measure of the possible elk herd". This season restricts the movement of elk, and snow often makes some natural foods unavailable. Range damage, as well as orchard and hay stack raids by elk usually occur in the winter.

Morrison (1946) found with domestic ruminants that more food is required for maintenance in colder weather and in northern climates. Fat animals fed abundant food are least affected by cold. Sick animals or ones with poor coats, or little body fat for insulation use more food to maintain body temperature.

Considerable heat is generated in the paunch of ruminants by digestion of cellulose by symbiotic organisms. In cold weather this heat helps maintain body temperature. Marston (1948) found that 6 per cent of the energy in cellulose was converted to heat by the symbiotic organisms. Prosser (1950) found the rumen of domestic ruminants to contain a mixture of bacteria, yeast, and ciliated protozoa, but that the cellulose digestion was carried out by the bacteria of the rumen. Products of cellulose digestion by bacteria are sugar and large amounts of fatty acids. Ruminants are thus able to maintain weight on foods generally classed as roughages.

A review of the literature regarding the feeding value, chemical composition, and digestibility of range forage shows the winter season to be generally most critical. Helmers (1940) noted a reduction of food

value in winter of several deer foods. Forbes, et al. (1941) shows that winter deer browse is of very low nutritive value. Cook and Harris (1950) found the nutritive value of browse, grass and forbes in Utah changed little through the winter season but the nutritive content in winter was lower than in summer. Chemical analyses alone do not give a complete picture of the nutritive value of vegetation, but they do provide a comparative measure and serve to show what constituents are deficient or present in excess. Digestibility trials are the only known method of determining the value of the plant constituents to an animal. No digestion trials have been conducted with elk, Table V (Appendix). Chemical composition of similar foods is an index to the probable value of foods used in this study.

Murie (1951) states, "Elk prefer grass ranges, especially in the winter, and grass is often the dominant item in the diet at any time of year when it is sufficiently available although naturally in certain environments, especially when grass has been grazed down or snow covered, other types of forage will be the chief food." He also states that many browse species are highly palatable; sometimes making up a large percentage of the diet, and many species should not be classed as emergency foods. Murie states, "Even when provided with good hay, elk will eagerly browse many species." Acer and Amelanchier are listed by Murie as being high in palatability and often are damaged by over use on deer and elk ranges. He classes Salix as very high, "if not actually highest in palatability", particularly on winter ranges.

Murie further states that necrotic stomatitis is by far the most important elk disease and is most prevalent on winter ranges that are

overstocked or where hay is fed. He gives this as a major argument against hay feeding. Grey (1950) concluded that elk need other foods along with hay to survive in winter. On the Oak Creek Game Range in Washington he reports a herd of 1200 elk fed hay during the winter of 1949 and 1950. A census of the dead elk in the area totalled 132, of which bone marrow examination was made on 97 animals. Ninety per cent of this number died of malnutrition as determined by the bone marrow examination.

It is evident that information derived from further research into the food requirement of elk is needed and such information could be applied to elk management. The review of recent big game feeding studies and related work yielded valuable information aiding in the design of the experiments reported here.

METHODS AND PROCEDURE

The pens were constructed during September, October, and November of 1951 on the Blackfoot-Clearwater game range fifty miles northeast of Missoula in the Blackfoot River Valley at an elevation of 4,500 feet. The game range is managed by the Montana State Game Department primarily as a winter range for deer and elk. The pens were located at the edge of the timber between the hay meadows of the headquarters ranch and the eastern slope of the low mountains in the center of the game range. This site was formerly frequented in winter by the resident elk, and the site is sufficiently isolated to prevent disturbance of the experimental animals.

The basic plan of the pens was six individual feeding units with facilities for feeding, watering, shelter for the animals, and provision for weighing the animals and the feed. The ground plan is illustrated in Plate 1. A small building served to store foods and to house the food weighing facilities. Details of pen construction, description of weighing facilities, and methods of weighing are given in the Appendix.

Forage Collection

Hay.--Irrigated meadow grass hay from the Blackfoot-Clearwater game range was used as one of the three diets tested. A portion of the hay land was selected as being uniform in species composition, as free from long-awned grasses as possible, and without a high percentage of clover. A grass hay of medium quality was desired, with several plant species represented, and near an average in nutritive quality for western Montana.

PLATE 1. Experimental feeding pens.

1. Large holding pen
2. Small holding pen
3-6. Feeding lanes
7. Weighing lane
8. Feed room
9. Animal scales
10. Feed bunks and shelters

Individual feeding lanes viewed from the south. The aerial photograph is taken from the north.


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Ten three foot square random samples were cut from the area selected on July 30th. Each sample was separated into species, air dried, and weighed. The average composition of species present on a weight basis is shown in Table I.

Table I.

PERCENTAGE COMPOSITION OF THE GRASS HAY BY WEIGHT OF SPECIES

Species	Per cent
Phleum pratense	37.1
Agrostis alba	39.1
Hordeum nodosum	.2
Agropyron repens	1.0
Poa sp.	.9
Carex longistivis	
C. festivela	
C. nebraskensis	13.5
Alsike clover	7.3
Taraxacum and Potentilla spp.	.6

The hay was cut and baled from the selected area on August 5th and 6th and stored in one of the large hay sheds at the game range headquarters.

Grass.--Stem cured native bunch grass was harvested from that portion of the Blackfoot-Clearwater game range known as Blanchard Flat on November 9, 1951. At that time considerable rain and snow had fallen since the end of the growing season. Weather records kept at the game range headquarters seven miles away, showed four inches of precipitation since September 1st, including two snowfalls of an inch or more. It was attempted to get as nearly as possible a grass similar in nutritive value to stem cured grass the foraging elk would find during the winter feeding period. It was believed that this amount of precipitation would have caused nutrient loss through leaching approximately equivalent to that which could be expected in forage collected in midwinter. The

PLATE 2. Composition of hay fed the elk.

1. Phleum pratense
2. Agrostis alba
3. Hordeum nodosum
4. Agropyron repens
5. Poa sp.
6. Carex spp.
7. Alsike clover
8. Taraxacum sp, Potentilla sp.


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work of Hart, et al. (1932), McCall (1939), Stoddard (1941), Helmers (1940), and Cook and Harris (1950) all seemed to indicate that this premise would probably be true.

The grass was cut with a sickle-bar mower and gathered with a sheet iron catcher fastened to the sickle bar. The supply of grass was stored unbaled in one of the hay sheds at the game range headquarters.

Composition of the bunch grass harvested from the area is shown in Table II. This is not a direct comparison with the composition of grasses in the hay. Samples were taken by the line intercept method and are therefore expressions of the amount each species makes up of the ground cover and not the weight of each species in the samples. This composition description was made on July 12, 1951. The density of vegetation as determined by the method was 0.36.

Table II.

Composition of the Bunch Grass by Vegetative Description

	Per cent
Festuca idahoensis	44.4
Festuca scabrella	20.8
Solidago sp.	9.7
Carex filifolia	7.3
Agropyron spicatum	6.2
Antennaria sp.	5.3
Senecio sp.	2.3
Erigeron sp.	2.0
Koelaria gracilis	0.7
Chrysothamnus sp.	0.4
Eriogonum sp.	0.4
Phlox sp.	0.2
Achillea millifolia	0.2

Browse.--Browse was collected at weekly intervals throughout the feeding period. The major source was the Flathead Indian Reservation lands two miles north of Evaro, Montana.(Plate 3). Ample ungrazed upland brush grew here on all but directly north facing slopes. Salix, tentatively

PLATE 3. Site of browse collection area near Evaro, Montana

PLATE 4. Example of browse utilization.

Salix Bebbiana above and Amelanchier Alnifolia below. Unbrowsed material is on the right and browsed material is on the left.

identified as S. Bebbiana and Amelanchier alnifolia were the major species available. Branches were cut at about three foot lengths with a machete-like corn knife, then skidded to the truck on a square of heavy canvas tied in a boat shape. The browse was trucked to the pens and stored under shelter until needed.

Other sources of browse were on Elk Creek, ten miles southwest of the pens where Acer glabrum was collected and other locations in the Blackfoot Valley for minor amounts of other browse species.

Feeding Methods

Hay and grass were fed in a similar manner. A known weight of food was presented to the animals each morning. Weights were taken to the nearest one-quarter pound. Approximately one-third more than the animals normally consumed was presented to be sure they would consume as much as they desired. The following morning the food remaining unconsumed was weighed on the Hanson dairy scale to the quarter pound. The amount consumed for the previous twenty-four hour period was then determined. A weight equal to the amount consumed of new feed was weighed out and added to the food left to bring the total weight up to the daily ration. At the end of each week the weight of food consumed during the last twenty-four hour period was determined. The remaining food was then discarded and a daily ration of new food presented. This was done to prevent use by the animals of only the most palatable species within the hay or the grass composite and thus provided a limited amount of preference but not completely free choice. Chemical analysis or even species composition of the hay or grass would have little meaning if the animals chose only plants most palatable to them.

Browse species were tied into five to ten pound bundles. This

was necessary to facilitate weighing and to keep the elk from scattering the feed. Approximately equal amounts of the two or three browse species were presented at one time. It was discovered early in the study that it was necessary to feed browse twice a day in order to have sufficient food material before the animals. Approximately one-third more feed than the animals could consume was before them each day. All of the browse bundles were weighed on the platform food scale before and after they were browsed.

Many of the feeding studies reviewed reduced all forage weights to an air dry basis. This was done when forages varied in moisture content, were lush and green, or precipitation fell on the feeds during the experiment (Moreland, 1951). This was found to be unnecessary for the hay and grass used in this study. Temperatures were almost invariably below freezing and the feed shelters protected the feed bunks and their content from snow and rain. Relative humidity was very low and essentially stable. This eliminated the need for adjustments for moisture content of hay and grass. Fresh browse was collected each week and had a higher moisture content. All browse weights were reduced to an air dry basis to make the weights of hay, grass, and browse comparable.

Experimental Animals

The experimental animals used were taken from the National Bison Range November 1, 1951. Prior to that time they had been used in a breeding study at the Bison Range (Cheatum, 1951). The animals were rounded up August 27, 1951, from one of the main pastures of the Bison Range and placed in a seventy-five acre enclosure. This enclosure had a grass cover and a small patch of cottonwood which was used heavily. On October 1, 1951, some of the animals were not breeding and appeared below normal

in condition. They were given a supplement of twenty percent protein pellet concentrate.[1]

Eight unbred adult cows and five calves were trucked to the feeding pens on October 31 and November 1, 1951. These animals were grouped in the half acre holding pen. Unfortunately weighing facilities were not completed at that time and the animals could not be weighed. From November 1st until December 31st the animals were fed hay and the same concentrate fed at the Bison Range. More hay was present at all times than the animals consumed. The average hay consumption was 13.3 pounds per adult animal per day and the average pellet consumption was .78 pound per adult animal per day. Two calves were considered equivalent to one adult. These figures are approximations of consumption based upon the average weight of sample bales and the total number of bales fed and on the total weight of concentrate consumed. Mixed browse was available for the last two weeks of the experiment although only traces of branch tips and buds were taken.

The animals were separated, weighed, and put on the experimental diets January 1, 1952. At that time their appearance and condition was better than when they first arrived at the feeding pens. It is not known, however, if they were in what could be classed as a normal early winter condition. In temperament they were better suited than animals brought directly from native range. During their previous confinement, they had become comparatively calm and were undisturbed by the activity or the presence of humans.

[1] Misco Range Pellets, Misco Mills Co., Missoula, Montana. Composition: 1% phosphorus, 2.5% fat, 9% fiber, 10% ash, 20% protein, 1.5% salt; contains grains, oil meals, minerals, and vitamin concentrate with added anise seed oil.

Weather Data

Weather records were kept throughout the feeding trials. An instrument shelter was mounted inside the pens. Maximum and minimum thermometers and a hygrothermograph in the shelter were read daily. Daily average wind velocities were obtained from a Robinson three cup recording anemometer mounted in the center of the feeding pens above the fence. Peak velocities were taken from a four cup anemometer located atop the feed building. Daily snow depth measurements were taken and water content of the snow was obtained with a rain gauge.

FOOD CONSUMPTION AND ANIMAL RESPONSE

Results with Hay

Animals #3 and #4 were placed together in one of the rectangular feeding lanes. Animal #7 was fed alone in the large holding pen. These three animals were of approximately equal weight. All five calves were grouped in the small holding pen.

Each adult animal was fed 15 pounds of hay daily. This ration was increased by one-quarter to 18.75 pounds daily for the paired animals from January 27th to February 25th. No increase in consumption was apparent and the ration was reduced to 15 pounds daily for the balance of the experiment. The five calves were fed 40 pounds per day or a daily ration of 8 pounds per day per calf. Consumption varied between 18.5 and 37 pounds of the 40 pounds. Daily consumption is illustrated in Figure 1a.

The above animals were fed hay throughout the feeding experiment. Animal #1 was fed browse for 28 days; then shifted to a 15 pound daily ration of hay throughout the last six weeks of the feeding study.

From January 1st until February 10th the daily consumption of each of the paired animals was significantly higher than the daily consumption of the animals fed alone. On February 10th, animal #7 and animal #4 were interchanged after weighing. The daily consumption of the new pen mates was less than the daily consumption of the original pair. The animal formerly fed alone did not gain in weight or lose weight any less rapidly when paired with another animal.

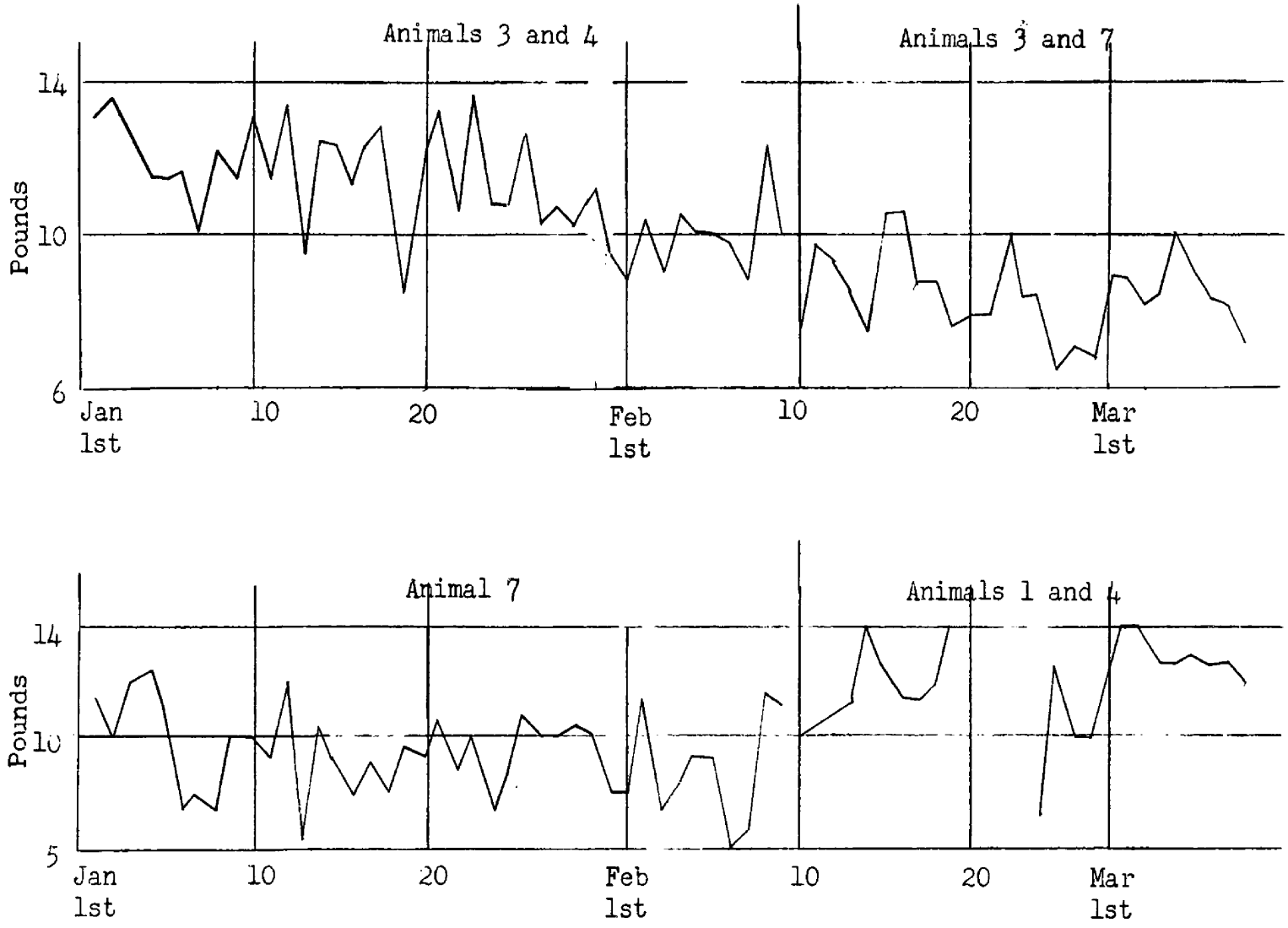


Figure 1a Daily Hay Consumption

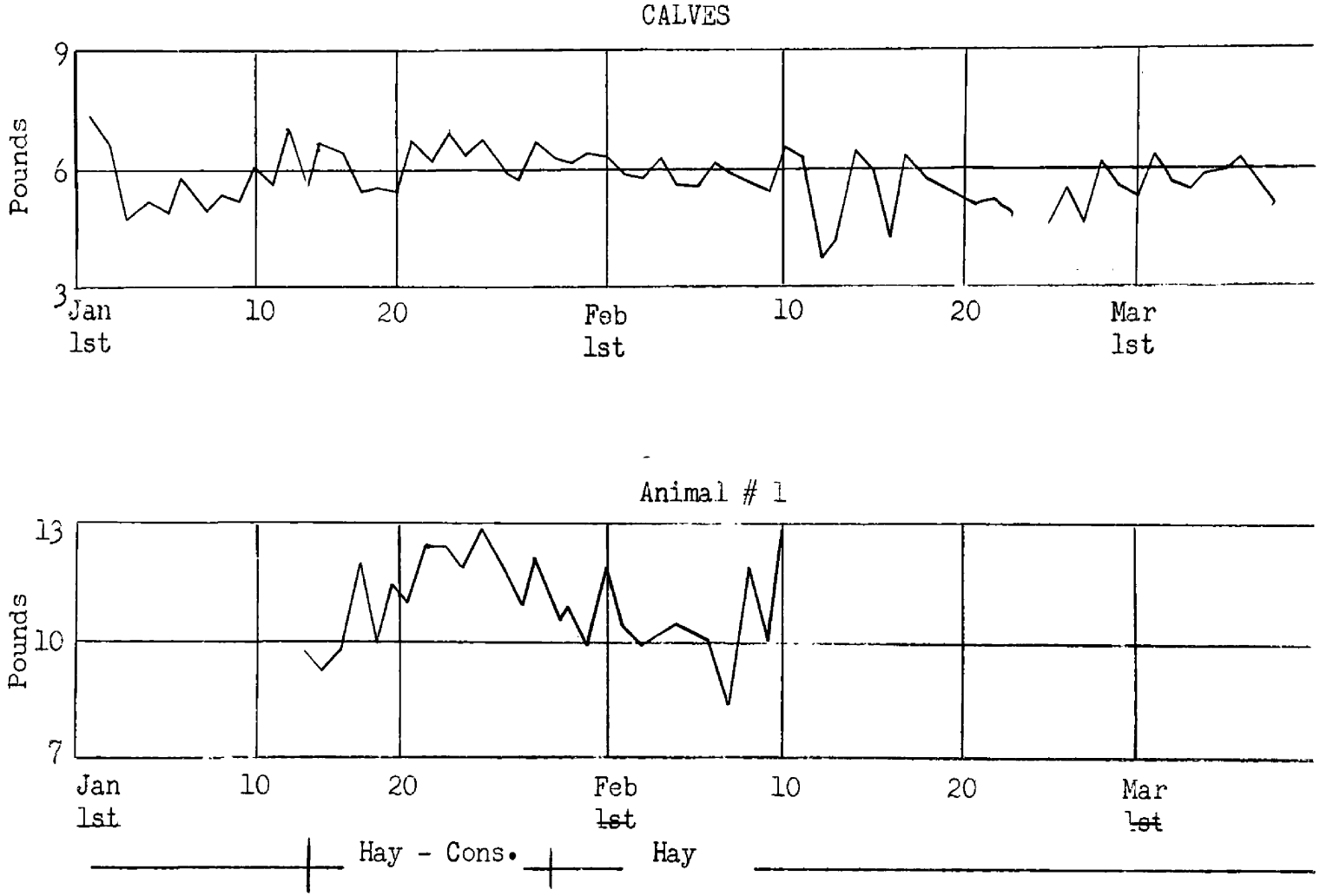


Figure 1b Daily Hay Consumption

The adult animals fed hay did not maintain their weight. Losses varied between 5.9 per cent for #4 to 10.6 per cent for #3. The average loss for the four adult elk fed hay was 8.3 per cent. Weight trends are shown in Figure 6.

Average consumption of the paired cows fed hay was 10.7 pounds per animal per day. The average consumption per hundredweight for these animals was 2.06 pounds. Average daily consumption of the cows fed singly was 8.27 pounds or 1.68 pounds per hundredweight. Daily consumption and consumption per hundredweight are compared in Figures 3 and 4. Animal #7 was the only animal fed singly on hay for the major part of the feeding study. The lower consumption per hundredweight for this animal might be due in part to her age. It was found at the conclusion of the experiment that this animal was 15 to 20 years old.

Average feed consumption for the calves was 5.83 pounds per animal per day or 2.3 pounds per hundredweight of calf. Calf weights at the end of the feeding study indicated an 0.3 per cent loss since the beginning of the feeding. Gains in weight of calves were recorded for the first three two-week weight periods. The day before the weights were taken for the fourth weight period, the calves were moved from their pen and disturbed by the temporary lodging of nine wild elk in the holding pens. Calf weights for the fourth weight period indicated a loss in weight of 2.7 per cent. The 0.3 per cent loss shown by the fifth and final weighing two weeks later was therefore a gain in weight of 2.4 per cent in two weeks. Continuous slight gains might have been recorded if the disturbance had not occurred. Weight trends for the calves are compared in Table IV.

A partial selection of plant species in the hay was shown by the

animals. Alsike clover and sedges were frequently taken first. No apparent choice was displayed for the other species in the hay except that the smaller stems and those of a dark green color were preferred to coarse yellowed or bleached stems. The animals would frequently eat in one spot in the feed bunk until they had formed a hole in the hay with their noses. Preference and manner of eating were similar in adults and calves.

Results with Grass

Animals #2 and #5 were fed together in one of the rectangular lanes. Animal #2 was largest, with an initial weight of 594.5 pounds. Animal #5 weighed 499.5 pounds at the beginning of the study. These animals were fed together and daily consumption and consumption per hundredweight of animal was computed as an average of the two. A large animal was purposely paired with a small animal to offset possible differences in consumption per hundredweight between large and small animals. There was insufficient individual feeding space to feed these animals singly throughout the experiment.

Thirty pounds of bunch grass, or a daily ration of 15 pounds per animal was fed from January 1st to January 13th. In addition to this, 7.5 pounds of hay were fed for the first four days to avoid possible ill effects from too abrupt a change from the hay diet given prior to the feeding experiment. On January 14th the grass ration was increased to 45 pounds to provide at least one-third more than the animals would eat daily.

On February 10th, animal #5 was moved to an adjacent feeding lane and the animals were fed separately. On February 20th, the last of the supply of grass had been used and the pair was put on a hay diet. They were fed together in the original feeding lane. Records were kept on

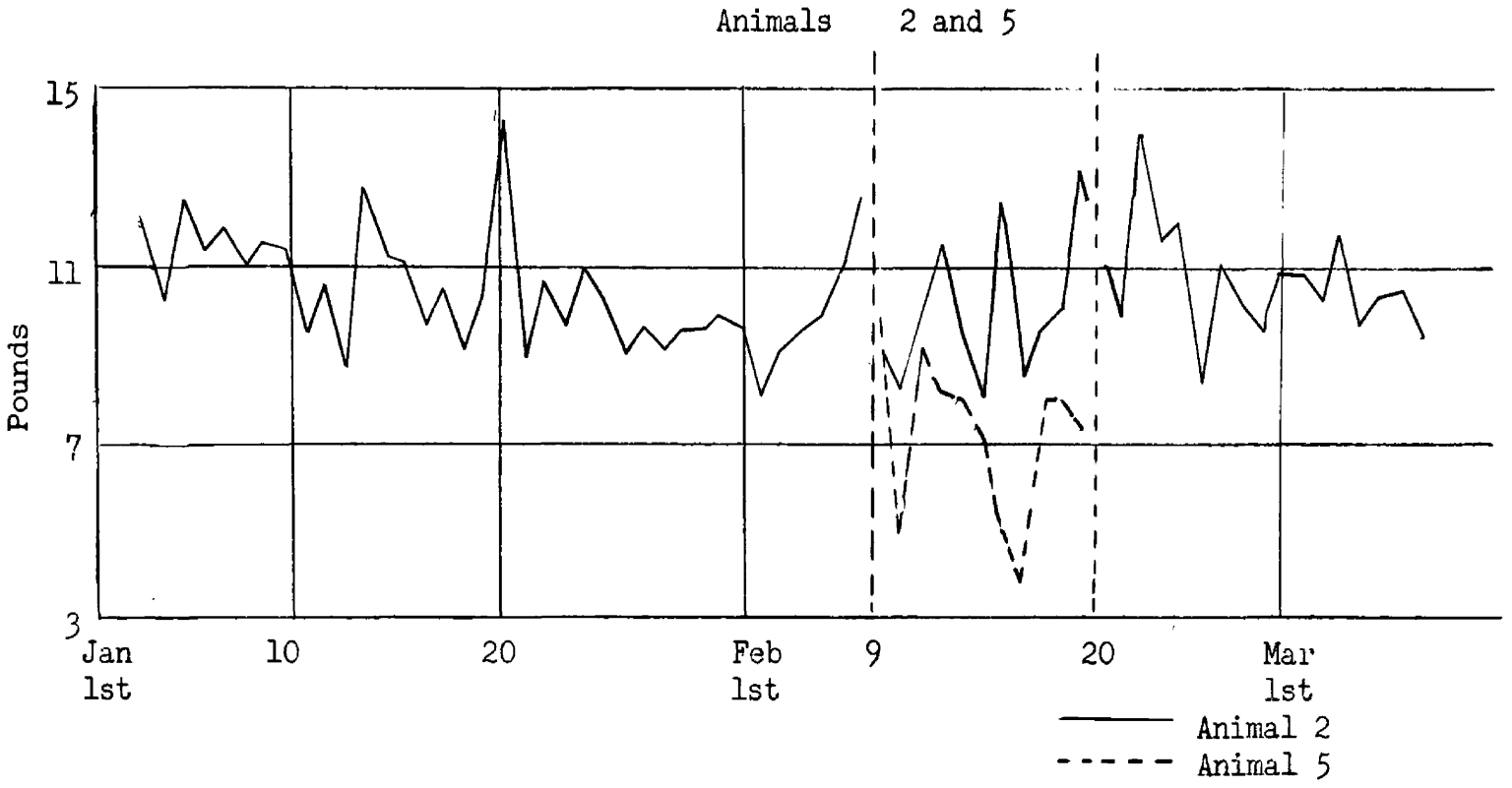


Figure 2 Daily Grass Consumption

hay consumption and animal weight changes until the end of the experiment on March 9th.

The animals did not maintain their original weight on the grass diet. Animal #2 lost 10 per cent and animal #5 lost 11 per cent by the end of the six weeks of grass feeding. Animal #2 gained 1.6 per cent and animal #5 lost 0.8 per cent during the sixteen days they were fed hay after the grass feeding was concluded. Weight trends are shown in Figure 6.

Average consumption of the pair on the grass diet was 10.4 pounds per day or 2.02 pounds per hundredweight. Total average consumption and consumption per hundredweight were higher when the animals were fed together than when they were fed in separate lanes. Average consumption of the pair on hay after the conclusion of grass feeding was 10.62 pounds per day or 2.16 pounds per hundredweight for the last seventeen days.

Little selection of plant species in the grass was shown by the animals. In general, the most weathered and coarser stems were avoided. Manner of eating was similar to that of the cows fed hay. Daily consumption and consumption per hundredweight of grass are compared with other diets in Figures 3 and 4.

Results with Browse

Animals #1 and #6 were originally put on a browse diet in separate feeding lanes. Extremes in size were selected to determine the possible differences in consumption per hundredweight. An estimated one-half ration or 7.5 pounds of hay was fed daily with the browse, for the first three days. For the next three days, 3.75 pounds of hay were given with the browse; then the animals were fed on browse alone after

two more days with 2.0 pounds of hay. Animal #1 ate no browse until the seventh day, and ate an average of only 4.54 pounds of browse per day for the next four days after hay was deleted. This was the end of the first two-week weighing period and she had lost 14.6 per cent of her original weight. She was given a full hay ration of 15 pounds daily and 0.25 pounds of 20 per cent protein concentrate with the browse. At the next two-week weight period she had regained 8.4 per cent of her 14.6 per cent weight loss and the concentrate was removed from the ration. She refused to eat browse with any hay present in the feed bunk. After two more weeks, further efforts to get her to eat browse were abandoned, and she was fed hay for the remainder of the feeding experiment.

Animal #6 began eating browse on the fifth day of the transition period. At the end of the first two-week weighing period she had consumed an average of 7.05 pounds of browse per day for nine days with a weight loss of 10.7 per cent. She was retained on the browse diet. At the end of the second two-weeks her weight loss was 18.7 per cent of her original weight and a 7.5 pound or half ration of hay was then given with the browse. She regained 5.5 per cent of the 18.7 per cent weight loss by the end of the third two-week interval and was again limited to a browse diet. The rate of weight loss decreased during the last four weeks but her final weight loss was again 18.7 per cent of original weight. The average consumption of browse was 9.44 pounds per day. Daily consumption per hundredweight averaged 2.16 pounds. These amounts are air dry weight of browse.

On February 26th, a native elk from near Lolo, Montana was placed on a similar browse diet. Seven and one-half pounds of hay were given in

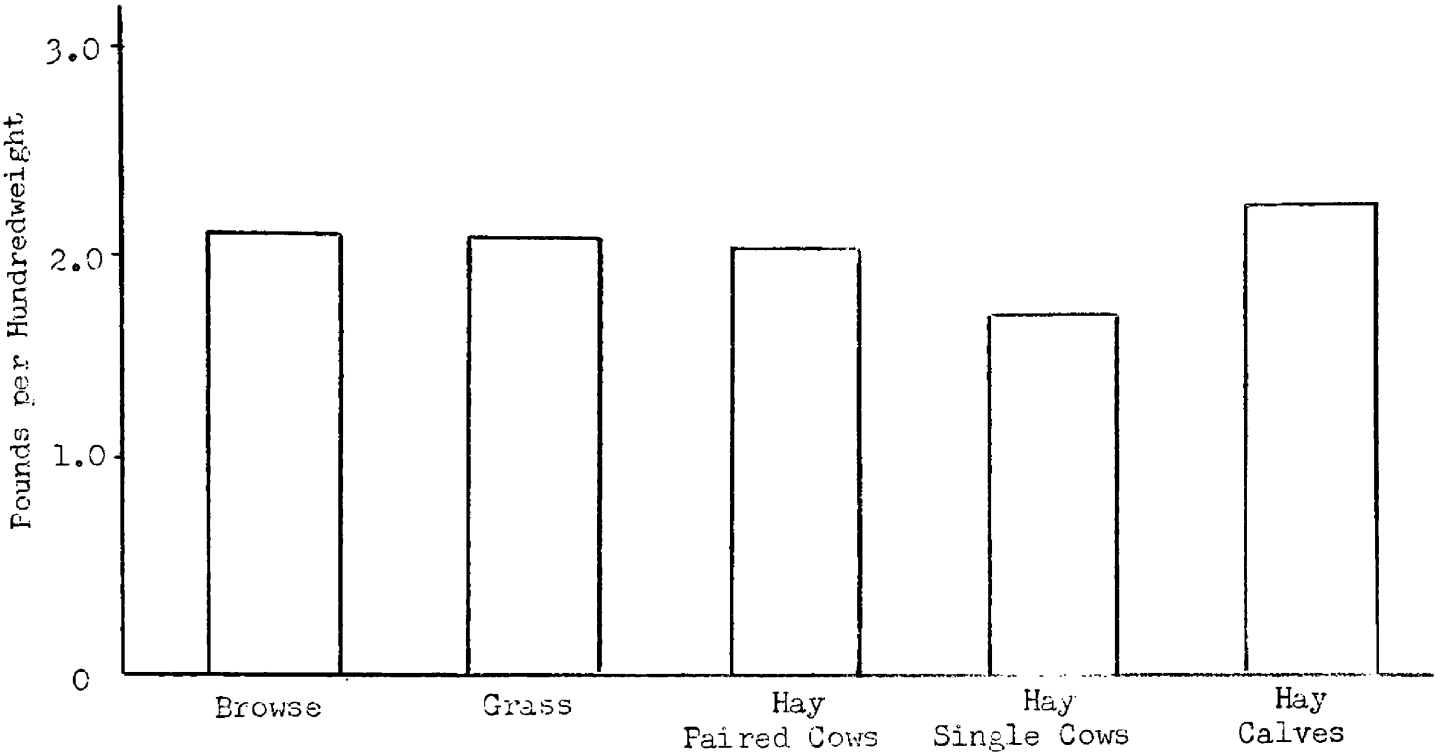


Figure 3 Average daily consumption of Air-Dry Material per hundredweight of animal.

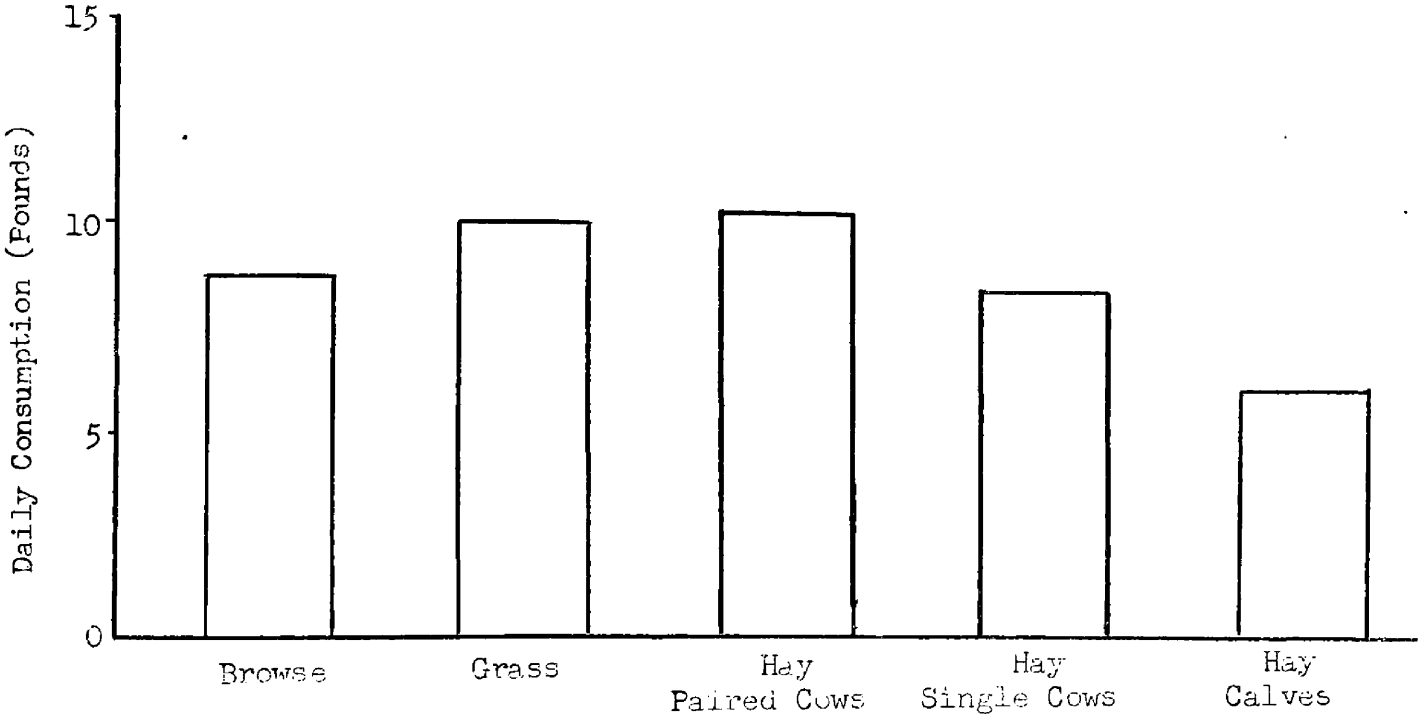
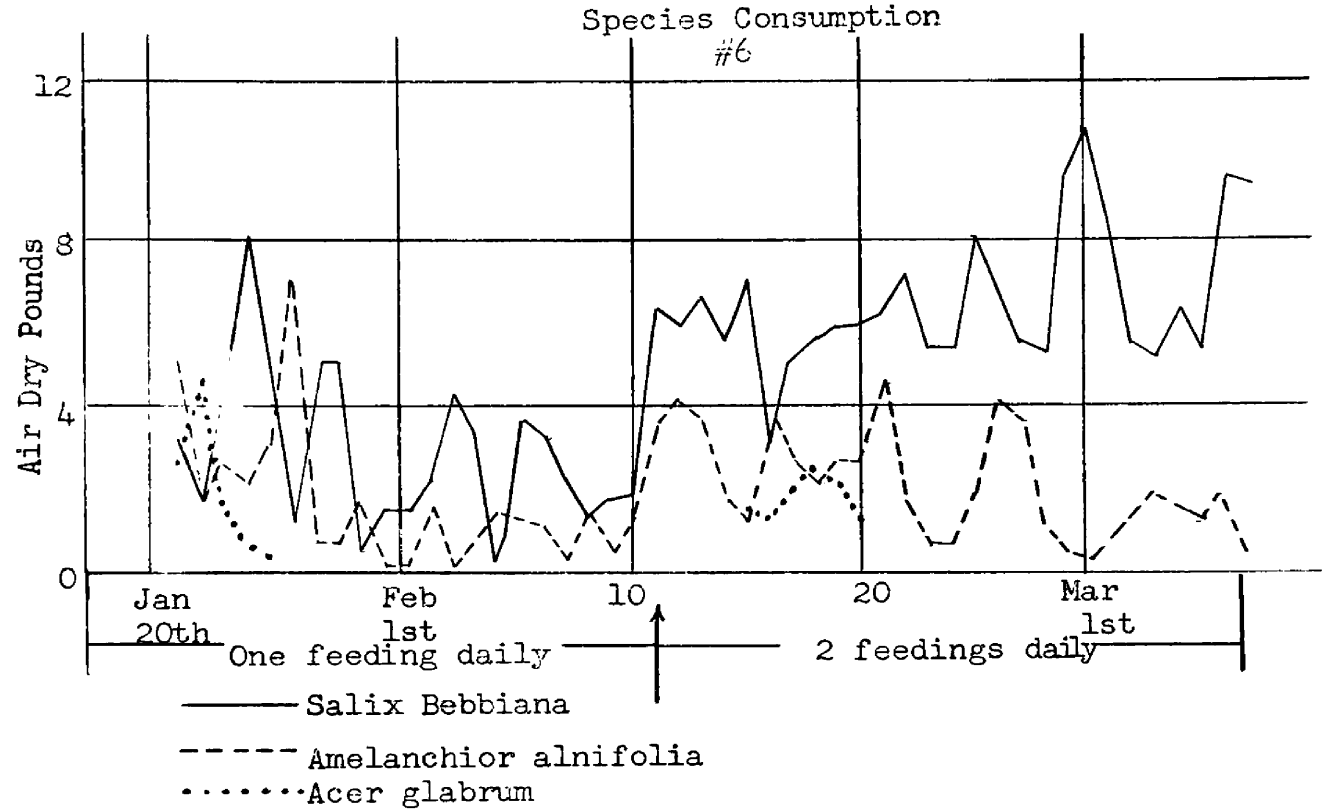


Figure 4 Average daily consumption in pounds of Air Dry material per animal.

addition to the browse for the first two days, and three pounds on the third day. From the first, this cow ate more browse than hay and readily ate browse until the end of the experiment. For the two-week period she consumed an average of 7.51 pounds per day and 1.05 pounds per hundredweight. A 7.9 per cent weight loss was recorded at the end of the experiment. Weight curves for these animals are shown in Figure 6.

Fifty to seventy-five pounds of browse were presented each day during the first four weeks of the study to animals #1 and #6. A total of 75 to 110 pounds were given in two feedings daily during the remaining six weeks to all of the animals fed browse. Unconsumed and apparently edible browse was always left by the animals. The estimated percentage left unconsumed varied from at least 50 per cent to less than 10 per cent. Generally at least one-quarter of the finer stems and tips were left. The average consumption of browse was 8.84 pounds per day. Daily consumption per hundredweight averaged 2.07 pounds per day. These figures are an average of the results with animal #6 and the animal from Lolo, Montana. Comparison of these figures with the other diets is given in Figures 3 and 4.



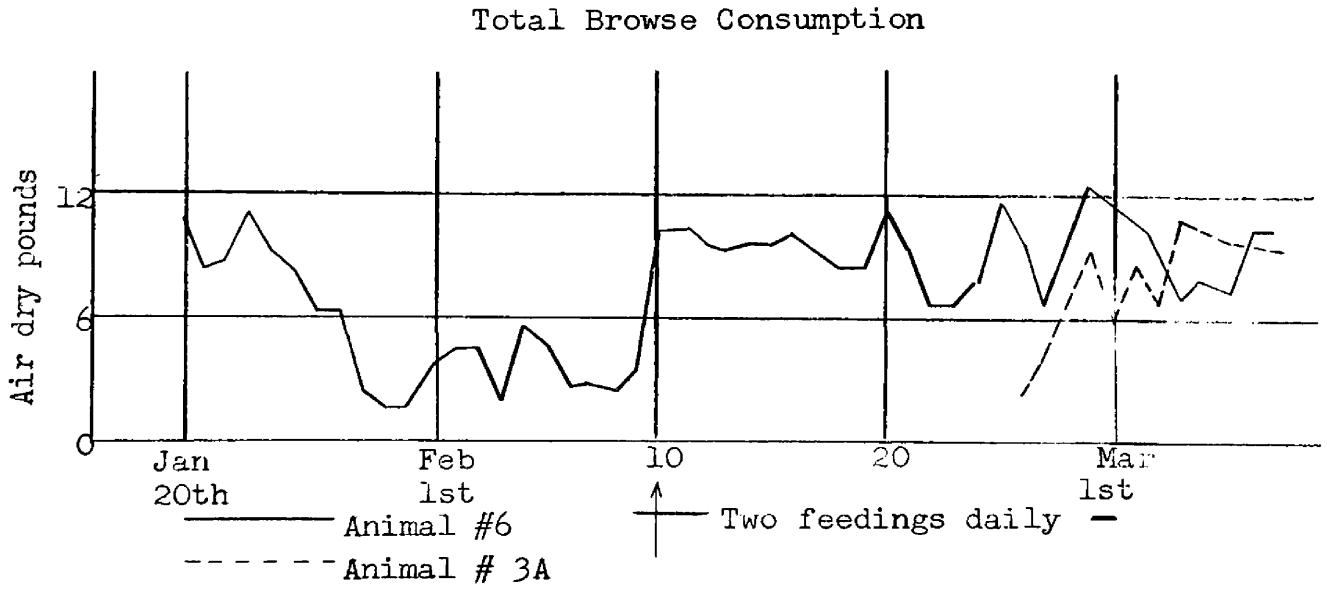


Figure 5 Daily Browse Consumption

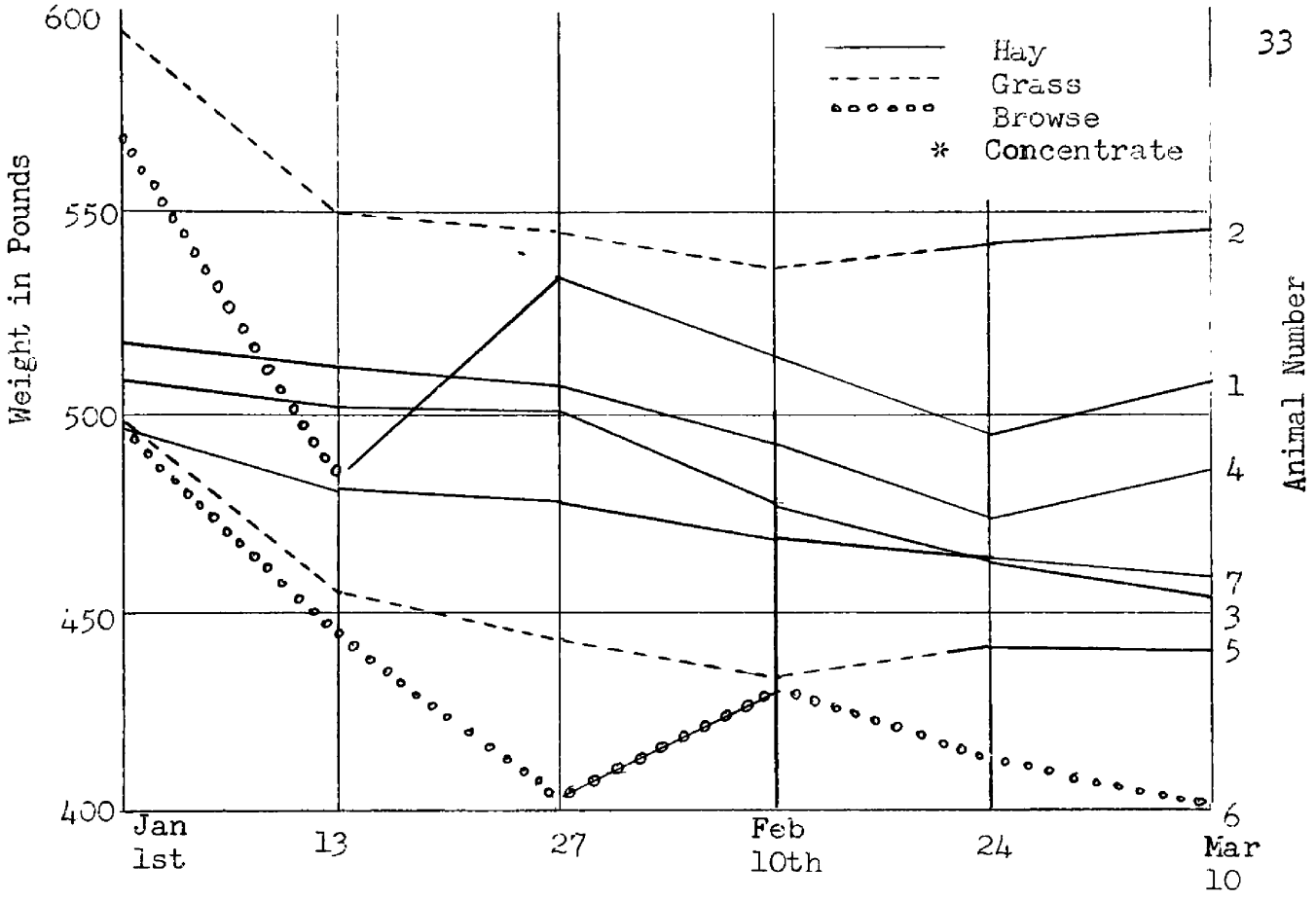


Figure 6 Change of Weight and Diet of Cow Elk.

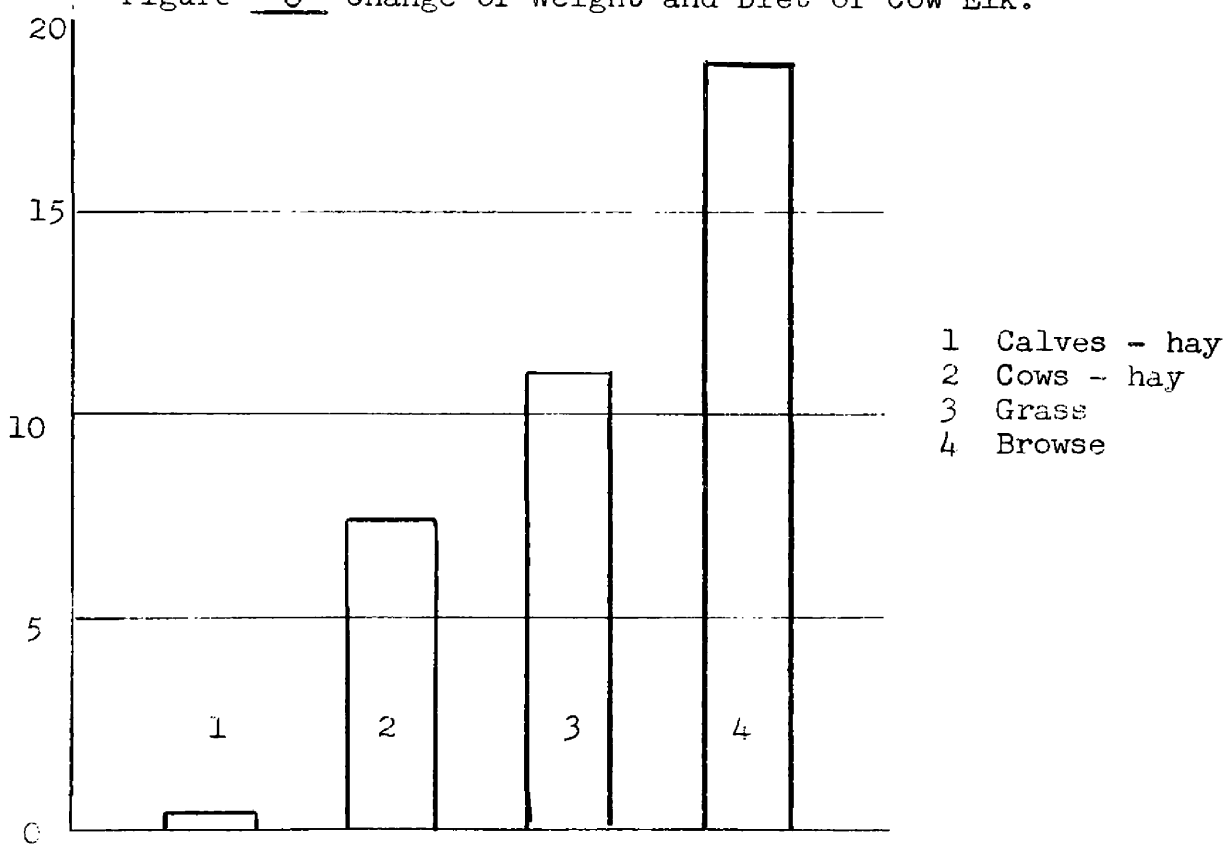


Figure 7 Average Per cent of Weight Lost

Table III

SUMMARY OF AIR DRY FORAGE CONSUMPTION AND WEIGHT RESPONSE OF ADULT ELK

Animal Number	Ration	Date	Average Consumption Daily (lb.)	Average Daily Consumption per Cwt. (lb.)	Animal Weight (lb.)	Gain or Loss from Original Weight (%)	Final Body Condition	Age in Years
1	-	Jan.1	-	-	468.5	-		
	Browse-hay	Jan.9-12	5.89	1.12	485.0	-14.6		
	Hay-concentrate	Jan.13-27	11.45	2.27	533.0	-6.2		
	Hay	Jan.27-Feb.10	10.5	2.0	513.0	-9.7		
	Hay	Feb.11-24	Feed not weighed		495.5	-12.8	Fair. Fat on	
	Hay	Feb.25-Mar.8	9.5	1.69	508.5	-10.5	mesenteries	15-20
2	-	Jan.1	-	-	594.5	-		
	Grass	Jan.8-12	11.45*	2.29*	550.0	-7.5		
	Grass	Jan.13-27	11.0*	2.20*	546.0	-8.2		
	Grass	Jan.28-Feb.10	9.6*	1.95*	536.0	-9.8		
	Grass	Feb.11-20	10.0	1.87	534.5	-10.0	Fairly good. Fat	
	Hay	Feb.21-Mar.9	10.4*	1.92*	544.5	-8.4	on mesenteries	7-8
5	-	Jan.1	-	-	499.5	-		
	Grass	Jan.8-12	11.45*	2.29*	457.0	-8.5		
	Grass	Jan.13-27	11.0*	2.20*	444.0	-11.1		
	Grass	Jan.28-Mar.10	9.6*	1.95*	435.0	-12.9		
	Grass	Feb.11-20	7.2	1.62	444.5	-11.0	Fair. Fat on	
	Hay	Feb.21-Mar.9	10.4*	1.92*	440.0	-11.8	mesenteries	6-7
6	Browse	Jan.1	-	-	497.5	-		
	Browse-hay	Jan.1-12	8.33	1.77	444.0	-10.7		
	Browse	Jan.13-27	9.61	2.04	404.5	-18.7		
	Browse-hay	Jan.28-Feb.10	11.01	2.63	431.5	-13.2		
	Browse	Feb.11-24	9.74	2.30	415.5	-16.5	Poor. No fat	
	Browse	Feb.25-Mar.8	8.49	2.07	404.5	-18.7	on mesenteries	9-10

Table III (Continued)

Animal Number	Ration	Date	Average Consumption Daily (lb.)	Average Daily Consumption per Cwt. (lb.)	Animal Weight (lb.)	Gain or Loss from Original Weight (%)	Final Body Condition	Age in Years
3	-	Jan.1	-	-	507.25	-		
	Hay	Jan.1-12	11.18*	2.19*	501.0	-1.2		
	Hay	Jan.13-27	11.67*	2.31*	501.0	-1.2		
	Hay	Jan.28-Feb.10	10.16*	2.06*	491.5	-5.1		
	Hay	Feb.11-24	8.9*	1.90*	461.5	-7.0	Fair. Fat on	
	Hay	Feb.25-Mar.8	9.0*	1.97*	453.5	-10.6	mesenteries	5-6
4	-	Jan.1	-	-	518.0	-		
	Hay	Jan.1-12	11.18*	2.19*	511.0	-1.3		
	Hay	Jan.13-27	11.67*	2.31*	507.0	-2.1		
	Hay	Jan.28-Feb.10	10.16*	2.06*	491.5	-5.1		
	Hay	Feb.11-24	No weight data		473.5	-8.6	Fair fat on	
	Hay	Feb.25-Mar.8	9.5*	1.93*	487.5	-5.9	mesenteries	8-9
7	-	Jan. 1	-	-	470.0	-		
	Hay	Jan.1-12	7.42*	1.53	482.0	-1.6		
	Hay	Jan.13-27	7.25	1.51	478.5	-2.3		
	Hay	Jan.28-Feb.10	7.90	1.66	469.0	-4.3		
	Hay	Feb.11-24	8.90*	1.90*	462.5	-5.5	Poor. No fat on	
	Hay	Feb.25-Mar.8	9.00*	1.97*	459.0	-6.3	mesenteries	15-20
3A	-	Feb.20	-	-	423.0	-	Very good	
	Browse	Feb.25-Mar.8	7.51	1.85	389.0	-7.9	condition	$3\frac{1}{2}$

*Average of paired animals

Table IV

AIR DRY FORAGE CONSUMPTION AND WEIGHT RESPONSE OF CALVES

Per cent of gain of loss is of initial weight. Diet was grass hay.

Animal Number	Initial Weight	Sex	Feeding Period Jan. 1-13		Feeding Period Jan. 14-27		Feeding Period Jan. 28-Feb.10		Feeding Period Feb. 11-24		Feeding Period Feb. 25-Mar.
Pounds	Jan. 1		Weight end of Period	Per cent Loss or Gain	Weight end of Period	Per cent Loss or Gain	Weight end of Period	Per cent Loss or Gain	Weight end of Period	Per cent Loss or Gain	Weight end of Period	Per cent Loss or
1	263.5	M	260.0	-1.3	266.0	+ 0.9	264.0	+ 0.2	258.0	-2.1	260.0	-1.3
2	251.0	F	252.0	+0.4	256.0	+ 2.0	257.0	+ 2.3	241.0	-4.0	247.0	-2.4
3	257.0	M	255.0	-0.8	259.5	+ 1.0	255.0	- 0.8	248.0	-3.5	275.5	+0.2
4	222.0	F	229.0	+3.1	234.0	+ 5.3	232.5	+ 4.2	225.0	+1.8	230.5	+3.8
5	271.0	M	274.5	+1.3	274.0	+1.1	272.5	+ 0.5	258.5	-4.6	266.0	-1.8
Average	252.9		254.1	+0.5	257.9	+ 1.9	256.2	+ 1.3	246.1	-2.7	252.2	-0.3
Average Daily Consumption		—	5.75		6.10		5.94		*		5.52	
Consumption per Cwt.		—	2.28		2.39		2.31		*		2.22	

* Consumption figures unavoidably lost. See page 52.

Table VI offers a comparison of the nutrients present in the three forage types actually used in these experiments. These figures were received too late to be incorporated into the text of this thesis.

Table VI

CHEMICAL COMPOSITION OF FORAGES USED

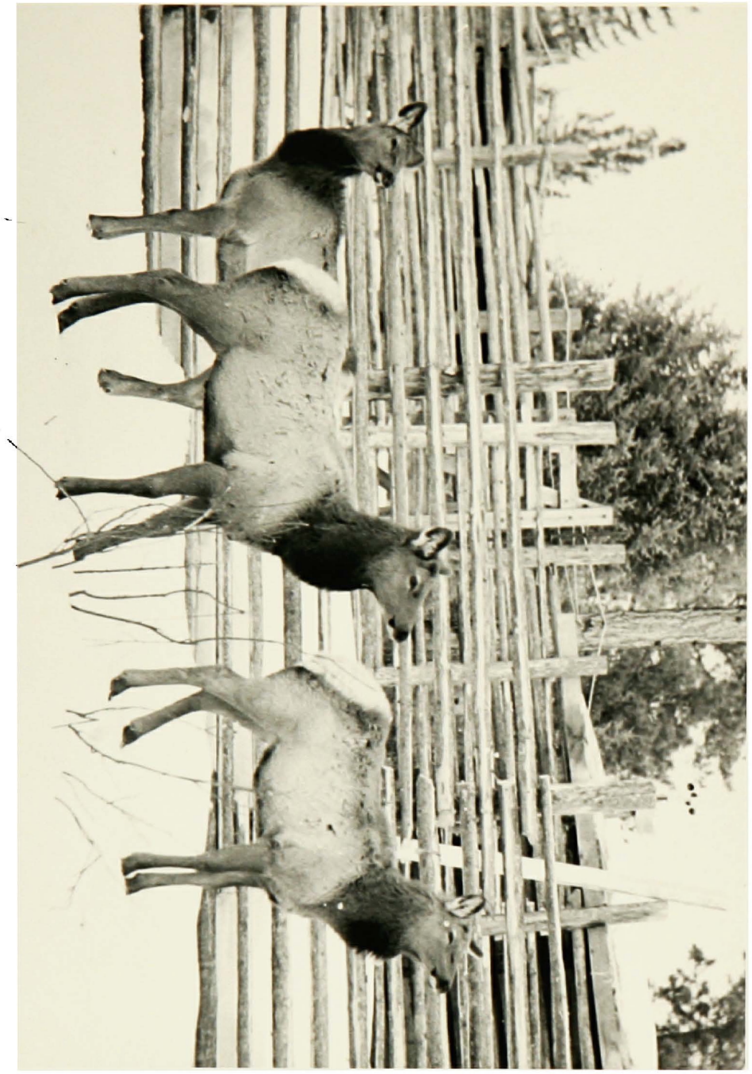
	Moisture	Protein	Ether Extract	Ash	Crude Fiber	Phosphorus	Calcium	Carotene*	Nitrogen Free Extract
Amelanchier alnifolia	3.5	4.5	3.0	3.2	26.9	0.11	1.65	3	58.9
Salix bebbiana	4.3	4.5	6.6	3.7	29.2	0.12	2.20	1	51.7
Acer glabrum	3.5	4.6	2.1	2.5	40.0	0.09	1.25	3	47.3
Meadow hay	5.2	5.3	1.7	5.5	31.3	0.15	0.50	6	51.0
Bunch grass	5.3	3.6	3.5	9.5	36.1	0.06	0.42	1	42.0
Bunch grass (Sun River)[1]	4.9	3.2	1.7	6.7	38.8	0.04	0.30	0.4	44.7

[1] Not fed to the experimental animals. Chemical composition of this Sun River bunch grass is presented for comparison with the bunch grass used in these experiments. The Sun River grass is known to be used by elk as a major part of their winter diet.

* micrograms/gram

PLATE 5. Hay diet. Animal #3 shown at the conclusion of the experiment on March 9th.

PLATE 6. Calves at the beginning and at the conclusion of the experiment. Center animal is #3. January 2nd above, March 9th below.



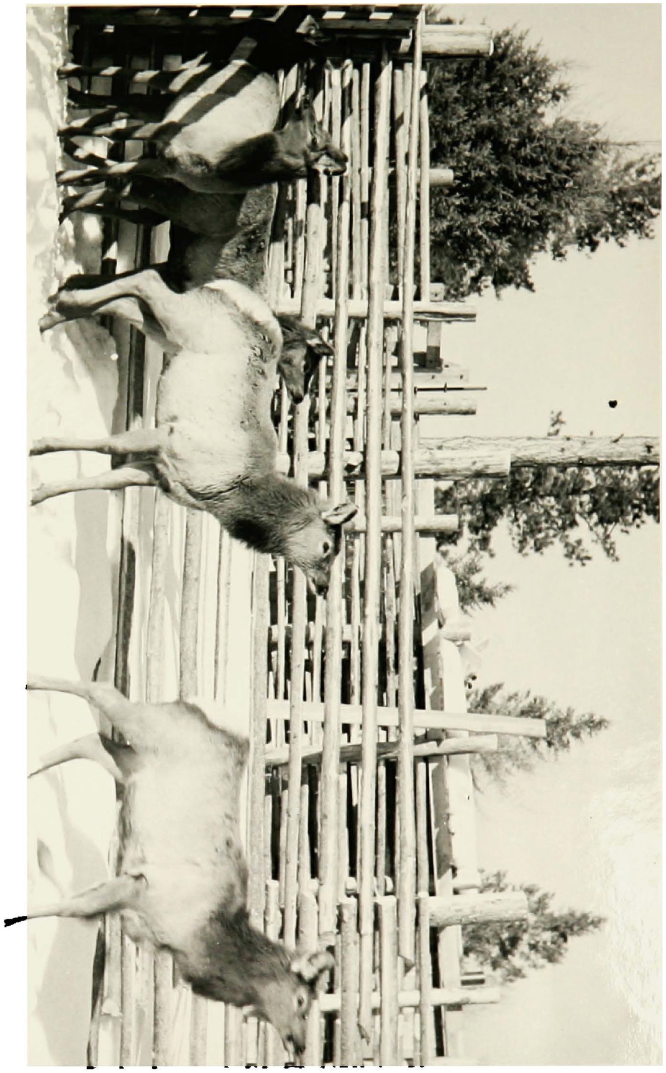


PLATE 7. Grass diet. Animal #2 shown at the beginning and at the conclusion of the experiment. January 2nd above, March 9th below.

PLATE 8. Browse diet. Animal #6 shown at the beginning and at the conclusion of the experiment. January 3rd above, March 9th below.

ADDITIONAL OBSERVATIONS

Browse Species Preference

Although the three major browse species were presented in approximately equal amounts, the animals generally ate more of the Salix. In order to obtain a measure of preference the daily average weight of each species fed was compared with the daily average weight of the material left uneaten. Salix was preferred with 18.9 per cent of the amount presented eaten, compared with 10.2 per cent of the Acer and 9.5 per cent of the Amelanchier. No apparent difference in palatability was shown between material collected in the Evaro area, Blackfoot River area, or the Elk Creek area. Lack of transportation and time prohibited a sufficient testing of other browse species.

Desire for Other Foods

Unbrowsed Amelanchier, represented by a few small bushes, was available in the large holding pen where animal #7 was fed and in the small holding pen containing the calves. These shrubs were untouched by the experimental animals but were readily browsed by the wild elk temporarily quartered in both pens. The only expression of a desire for a different food was made by animal #3. On February 28, 29, and 30th this cow was seen to nibble at the bark of the lodgepole pine rails of her pen. Calves #1 and #3 on the opposite side of the fence attempted to imitate her action. Only a fraction of a pound of food was taken. This action may have started in an attempt to get a little more Alectoria lichen from the poles. Most of the strands of Alectoria were removed from the

poles soon after the animals were placed in the pens.

Water Consumption

Fresh snow was available to the animals at all times. The water troughs were filled at two to three day intervals. No apparent correlation between diet and desire for water was apparent. In general the animals satisfied their thirst by eating snow instead of by drinking water.

Salt Consumption

A block of unmineralized stock salt was frequently used by the animals for a short time after they arrived at the pens from the Bison Range. Little desire for salt was evident during the experimental feeding. One-quarter pound quantities of dairy salt were presented on February 10th in small containers under the feeding shelters. Most of the original quarter pound remained one month later.

Influence of Weather

The effect of weather factors on weight trends and forage consumption are difficult to interpret. Neither cold weather nor falling snow caused any apparent discomfort to the animals. They were never observed to use the shelters or even the protection of the trees to escape weather factors. Wind velocities were generally very low because of the sheltered location of the feeding site. Temperature, wind velocity, and snowfall fluctuations shown in Figures 8 and 9 show little correlation with feed consumption and weight trends. However, there is a slightly higher food consumption during the colder periods of January 1st to 4th, February 23rd and 24th, and March 6th and 7th. Further experimentation during a winter period with a greater temperature fluctuation might show an increase of forage consumption during colder periods.

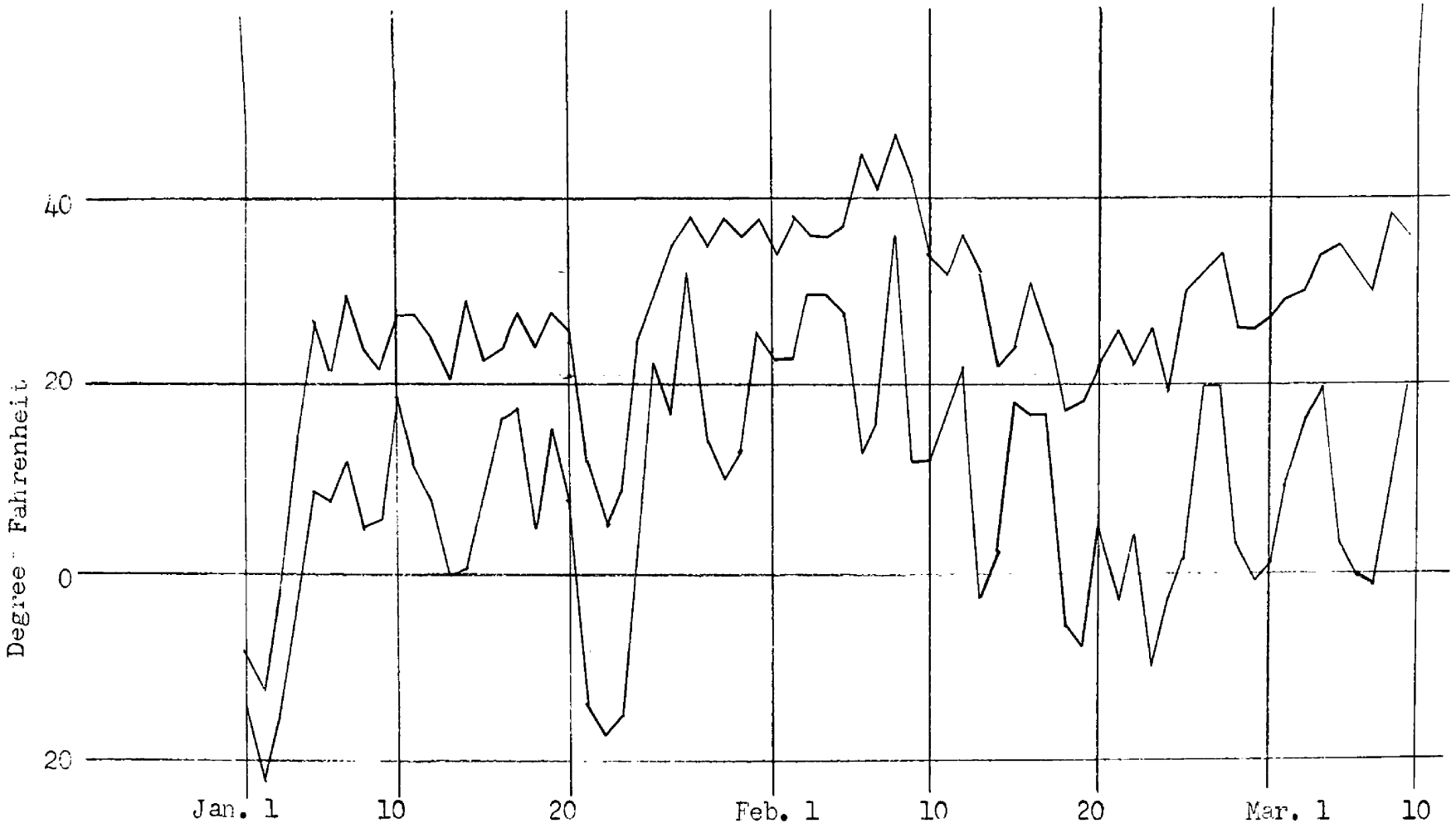


Figure 8 Maximum and Minimum Temperatures

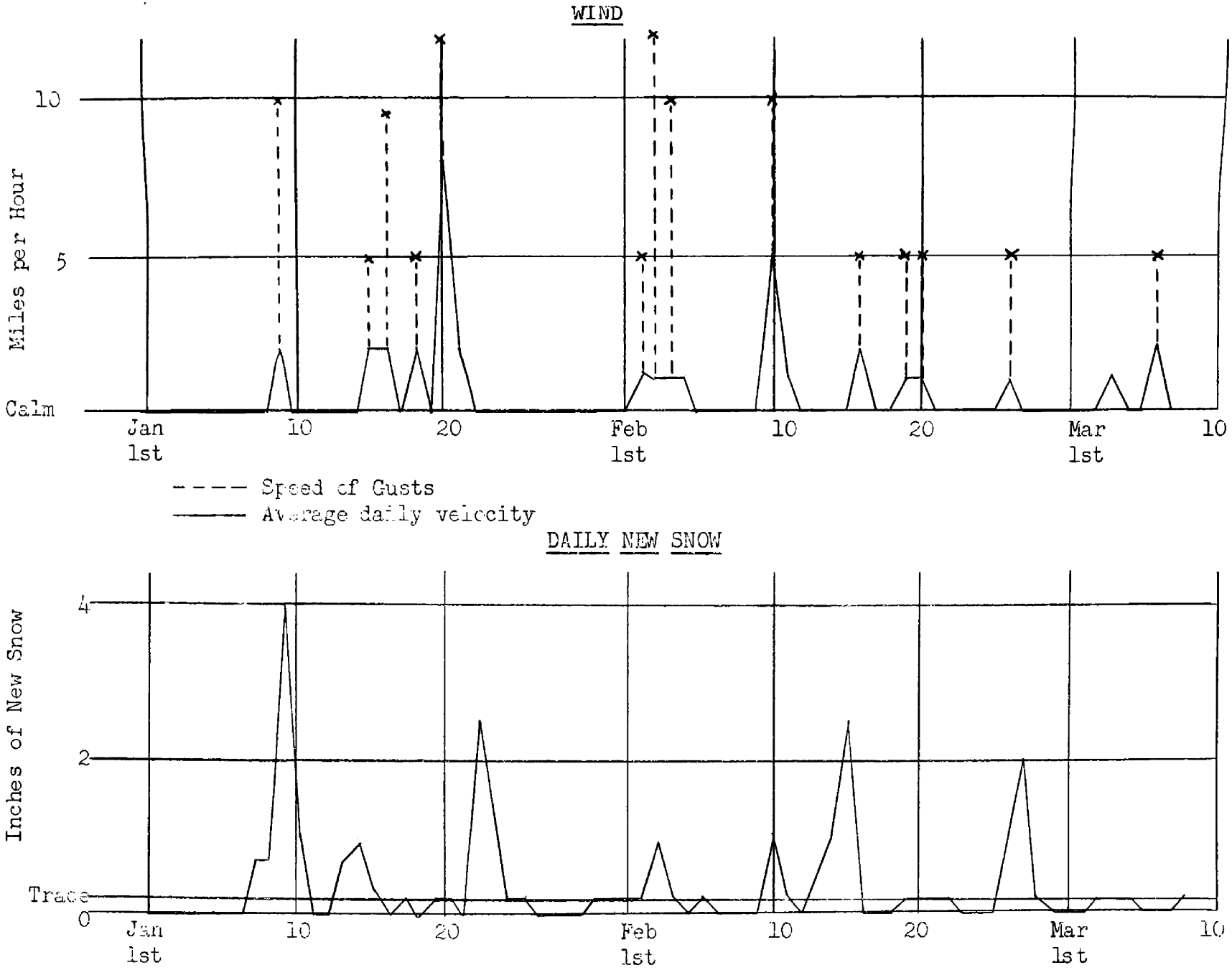


Figure 9 Variations in Wind Velocity and Snowfall.

Temperament and Compatability

The adult cow elk from the National Bison Range had become accustomed to confinement and the presence of humans. After the initial weighing of these animals, the process did not seem to frighten them excessively. The only outward sign of disturbance was occasional shivering when they were in the weighing chute. Anger at being herded was more often expressed by grinding of the teeth or striking with the forefeet. This was only done when the animals were weighed or otherwise excessively distrubed. There were definite differences between the animals in temperament, but weighing was only done at two-week intervals. All of the animals were calm except during the weighing process and therefore the effects of these disturbances on feed consumption are considered minimal. The calves were more nervous and excitable during the weighing but were also peaceful except at these times. The animals from near Lolo, Montana, were very nervous and excitable when kept in the large holding pen. When penned in the rectangular feeding lanes with the other experimental elk on each side in adjacent lanes, they were calm except during the weighing process. Two pairs of cows were fed together for extended periods. Numbers 2 and 5 would eat side by side under the feeding shelter. Number 4 of the other pair always ate before #3 but offered no objection to her feeding later. The calves would all feed together and threatened each other only in play.

Mortality and Injuries.

Eight cows were originally brought from the Bison Range on November 1st. Animal #8 apparently lost weight and exhibited symptoms of a diseased condition. She was killed and autopsied December 22nd No

evidence of disease was found and old age (15 to 20 years) was diagnosed as largely responsible for her condition.

Three cows and one calf trapped by the Montana Fish and Game Department near Lolo, Montana, were brought to the feeding pens February 19th. One of the cows was placed on a browse diet. Three days later she was found dead. Autopsy revealed no disease and no injuries due to the browse feeding. Extensive internal injuries of mechanical origin and probably due to trapping and shipping were the apparent causes of death. A second cow designated as #3A was then put on a browse diet. She was used until the end of the study. When this animal was being herded to the weighing chute on March 9th for the final weighing, she attempted to jump a fence and caught her foot between the rails and broke her right hind leg. It was necessary to shoot her.

Minor abrasions and loss of hair occurred during the first weighing periods, particularly to the calves. Animal #3 got a sliver in the left hind foot when her initial weight was being made on December 30th. A slight swelling was last noted on February 24th. Animal #5 had a small abscess below her left ear apparent from February 24th until the end of the study. The other animals were free from observed injuries during the feeding experiment.

Pellet Group Counts

Frequent snow made it difficult to make an accurate enumeration of daily pellet groups. Counts of pellet groups were taken on February 11th, 13th, and 29th. The results are listed consecutively as follows:

5 calves, 55 groups. 5 adults, 56 groups (10-12 per adult)
5 calves, 59 groups. 5 adults, 55 groups (9-13 per adult)
5 calves, 51 groups. 5 adults, 55 groups (10-12 per adult)

The average number for five cows and five calves for these three times counts could be made was 11 pellet groups per animal per day.

Final Animal Condition

After the conclusion of the feeding experiments, the animals were trucked to the National Bison Range on March 12th and 13th. The calves were released and the seven adults autopsied on March 14th. Animal #1, fed browse and hay; animals 3 and 4, fed hay, and animals #2 and #5, fed grass were all in quite similar body condition. There was some noticeable fat between the hide and the body cavity but stringers of fat were evident within the body cavity on the mesenteries. Animal #7, fed hay and animal #6, fed browse were without fat on the mesenteries, but had an amount of fat on the heart similar to the other animals. The calves were not closely checked for oral injury or necrotic stomatitis infection but examination of the cows showed no sores or infection in the mouth and throat. The lower jaws of the adults were checked with a known-age elk jaw collection at Montana State College. The probable ages of these elk are shown in Table III. The oldest animals were those found to be in the poorest condition. Number 7 as well as #8, killed and autopsied before the feeding experiment, were both 15-20 years of age. Number 6 was 9-10 years of age.

DISCUSSION

The job of building the feeding facilities, obtaining the animals, and collecting the three types of forage tested was the most difficult part of this experiment. Additional experimentation is planned by the cooperating agencies to make further use of the feeding facilities. The results obtained so far should be tested and extended by further feeding experiments with elk.

The feeding and weighing facilities were suitable for their intended purpose. Animal weights and weights of forage consumed were readily measured. Food collection methods were adequate for the number of animals fed, but would have to be expanded if additional animals were used.

The method of feeding and the results obtained in a hay feeding experiment with cattle by Shipley (1948) were remarkably similar to the hay feeding part of this study. Elk probably resemble domestic cattle in their ability to utilize hay as a maintenance ration. Adult cow elk were able to eat hay alone for 68 days during this experiment without excessive loss for the winter season. Calves and adults were able to eat this grass hay without oral injury or infection from necrotic stomatitis.

The two cows fed native bunch grass for 49 days lost only slightly more weight than the animals fed hay. The 10 per cent and 11 per cent weight loss suffered by these two elk was believed to be normal for the winter period. Several authors refer to elk wintering on grass ranges and Murie (1951) indicates that elk prefer grass ranges, especially in

the winter. Apparently cured bunch grass has not been previously tested by feeding trial as a winter elk diet. Chemical analysis of dry bunch grass reveals a low energy content in comparison with other forages (Table V, Appendix). Elk must have the ability to fully utilize these nutrients.

Results of the browse feeding conducted in this study were not conclusive. Animal weight loss was excessive on the straight browse diets. Several factors may have caused the inability of these animals to utilize the nutrients in browse (Table V, Appendix). The National Bison Range does not have extensive browse areas and browse constitutes a very minor part of the winter diet of the elk inhabiting this range. Upon their removal to the feeding pens, they were maintained largely on a grass hay diet from November 1st until January 1st when browse feeding was begun. Adjustment by these animals to such a different food in mid-winter may have been incomplete. The symbiotic bacteria of the digestive tract may possibly have been inadequate for digestion of this woody browse cellulose. Burroughs, et al. (1950) indicated, however, that in domestic ruminants a variation of numbers of bacteria of a given type occurred with various forage types eaten; but all types were present regardless of diet. It is not known whether the bacterial population adjusts itself to the diet type in elk. The experimental animals were gradually shifted from the hay diet to the browse as suggested by Howe, et al. (1947) in changing the feed of cattle.

The browse fed animals fed for a longer time each day than the animals on grass or hay. This appeared necessary in order to obtain enough bulk of browse tips and buds to satisfy their appetite.

The wild elk from Lolo, Montana, accepted the browse diet readily and her initial consumption was higher than the initial consumption of the Bison Range animals fed browse. The Lolo elk was fed only for two weeks on browse and the abnormal loss of body weight might have been partly due to her adjusting to confinement. This animal was relatively calm, however, except during the weighing process and her daily consumption did not markedly increase toward the conclusion of the experiment.

A variation in nutrient quality of the browse fed these animals might have occurred. All of the material was collected from similar appearing slope, exposure and apparently similar shrub growth. Slight variations in soil type or other factors might have caused differences in food quality. However, dissatisfaction with the shrubs was not shown by the animals. Browse samples were taken from varied locations and from shrubs currently browsed by wild deer or elk. Utilization of this sample material by the experimental animals appeared similar to the browsing of material making up the bulk of the browse diet.

Evaluation of these preliminary results of feeding browse to elk indicate that browse is not a preferred winter diet. The apparent nutrients in browse revealed by chemical analysis may not be of sufficient digestibility. The results obtained in this experiment should be supplemented with additional feeding trials. A diet containing more browse species and in greater quantity of each might allow the elk to choose a combination of food species that would maintain body weight. Digestibility trials with elk would demonstrate the degree to which elk utilize the nutrient constituents known to be present in browse species. The variation in digestibility between individual elk should be tested as well as

the digestibility of similar browse species collected from different areas. It is known that browse often makes up a large percentage of the diet of elk, particularly at certain seasons and in limited areas (Young and Robinette, 1939). Further experimentation is justified in order to correctly evaluate the extensive browse ranges used by elk in Montana and other western states.

SUMMARY AND CONCLUSIONS

These experiments were designed and conducted to further the knowledge of the quantitative food requirement for Rocky Mountain elk (Cervus canadensis nelsoni) during the winter season. In the summer and fall of 1951, feeding pens were constructed on the Blackfoot-Clearwater Game Range to feed elk in a manner similar to methods used with deer and domestic ruminants. A supply of meadow hay of known composition was collected in July and a supply of stem cured and naturally leached native bunch grass was gathered in November. Native browse plants were collected at weekly intervals throughout the course of the experiment. Eight adult cows and five calves of both sexes from the National Bison Range were fed. Two cow elk trapped in the wild near Lolo, Montana, were also used during the latter part of the feeding period. The weight of all experimental animals was taken at two-week intervals. Daily food consumption was recorded. Complete weather records were kept and the animals desire for salt and water noted.

Three adult animals and five calves were fed an unrestricted diet of hay for 68 days. The adult animals consumed daily an average of 10.7 pounds per animal or 2.06 pounds per hundredweight. The average loss of body weight for the adult elk fed hay was 8.3 per cent. The calves consumed 5.83 pounds per animal per day or 2.3 pounds per hundredweight. The calves made continuous increases in body weight until they were unfortunately disturbed during the later part of the study when moved from their pen to provide temporary quarters for nine wild elk trapped by the game department personnel. Final average weight was 0.3 per cent less

than the initial average weight.

Two adult cows were fed an unrestricted diet of cured bunch grass for a 49 day period. Average daily consumption was 10.4 pounds or 2.02 pounds per hundredweight. The average loss of weight for these animals was 10.5 per cent for this period.

One adult cow was fed an unrestricted diet of three native browse species for a 28 day period. A hay supplement was added to the browse for a 14 day period. Browse alone was fed for another 28 day period. The hay supplement was given because of excessive weight loss during the first period. The average daily browse consumption was 8.84 pounds of air dry material per day or 2.07 pounds per hundredweight. Final weight of this animal was 18.7 per cent less than her initial weight. Rapid weight loss was recorded for two other cows trapped from the wild and fed browse for 14 day periods.

The weight losses for the animals fed hay and grass was believed to be near normal for the winter period. Losses may have been increased slightly because of the unnatural conditions induced by the experiment.

The results of the browse feeding were inconclusive. They indicated, however, that more browse than hay or grass is needed per hundredweight of animal. Browse alone may be an inadequate winter maintenance feed. Further experimentation with additional animals from browse ranges should be profitable. More species of browse should be fed and in larger quantities daily. Paired animals may show more consistent results. Uniformity of age and size would be desirable.

Winter weather undoubtedly increases the maintenance requirement of elk. This was not, however, clearly demonstrated in these experiments.

Elk were discovered to be good experimental animals. They adjusted themselves well to feeding and weighing processes. Further experimentation is recommended using more animals and allowing ample time for the animals to adapt themselves to the experimental diet and confinement.

APPENDIX

Description of Feeding Pens and Weighing Facilities

The four rectangular units are 16 by 85 feet with wedge shaped passages leading to the weighing lane. Two larger units, the smallest 85 feet square were made from the original one-half acre holding pen (Plate 1).

Each of these six units was equipped with a feed bunk 4 feet by 8 feet and one foot deep. These were constructed with wooden frames fitted with galvanized iron troughs. A shelter roof over each feed bunk protected the animals and kept snow from mixing with the food. In each of the four rectangular lanes, access to the feed bunk was possible through a 2 by 8 foot hinged horizontal door forming a back wall to each bunk. Access to each bunk was therefore possible without actually entering the main lane. Browse species were held in the feed bunk by clamping this door down across the base of the branches. Three wooden water troughs were provided for the six units. Water was not available to each of the animals at all times, but ample fresh snow was present and the animals used little water. The troughs were filled by a bucket and could be moved from pen to pen as needed.

Fences were constructed of four to six inch lodgepole pine rails spiked to posts eight to twelve inches in diameter. The fence was a minimum of eight feet high throughout the pens. The gates were made adjustable for snow depth and could be adjusted up and down on a vertical one and one-half inch pipe fastened to the gate post by threaded half-inch ring bolts. Planed two by six inch lumber and three-eighths inch bolts were

used in gate construction. All gates were made six feet wide and seven feet high. Gates and fences were made as sturdy as possible, and care was taken to prevent possible injury to animals by projecting corners, pole stubs and bolt ends.

Weighing facilities consisted of a thirty-four by forty-four inch, 2000 pound capacity, Fairbanks-Morse platform scale mounted on a concrete slab with an enclosed weighing box two feet wide, six and one-half feet long, and seven feet high, permanently mounted on the scale platform. The animals entered a six foot weighing lane constructed at right angles to the wedge shaped passages leading from the rectangular feeding lanes. As shown in Plate 1 the weighing lane (7) was divided at the scales; the scale platform and box occupied half of the lane (9) and the other half served as a return lane after the animals were weighed. The balance beam of the scales projected into the building used for storing and weighing feed (8). An extension of the eaves of the building covered the scale platform and weighing box.

A small Fairbanks-Morse platform balance weighing to the nearest quarter pound was mounted from the ceiling of the storage and weighing building. A crossbar of the balance platform was connected at each end to the bundles of feed as they were weighed. Large bulky bundles of light feed could be weighed in this manner.

The weight of hay or grass left in the feeding bunks was measured to the quarter pound by a Hanson dairy scale with a sixty pound capacity. Time was saved by reading the weights at the feed bunk with the dairy scale rather than carrying the food from each feed bunk to the scale house. The dairy scale was checked against the small platform scale daily to assure accurate weights of food unconsumed.

Table V

Chemical Composition of Forage Comparable to the Forages Fed the Experimental Elk

Plant Species	Date	Place	% Moisture	% Protein	% Ether Ext.	% N-free Extract	% Ash	% Fiber	Source of Information
Acer glabrum	Nov.-Mar.	Taiga, B.C.	45.31	5.91	2.42	54.15	4.20	33.32	Cowan (1950)
Salix scoulariana	Nov.-Mar.	Taiga, B.C.	46.73	5.91	4.12	55.18	4.35	31.86	Cowan (1950)
Salix humilis	Winter	Pennsylvania	48.10	3.67	2.25	24.71	-	18.99	Forbes (1941)
Amelanchier florida	Nov.-Mar.	Taiga, B.C.	42.34	5.45	3.17	58.52	4.39	28.52	Cowan (1950)
Amelanchier alnifolia	Apr. 27	Jackson Hole or Yellowstone	5.99	5.16	3.19	50.33	2.61	32.72	McCreary (1931)
Wild hay	-	Central Montana	-	7.47	2.78	48.38	8.24	33.12	Green (1934)
Timothy hay	-	Central Montana	-	6.73	2.33	50.77	6.90	33.27	Green (1934)
Timothy hay	-	-	-	6.2	2.6	44.8	4.8	30.3	Morrison (1946)
Clover-timothy hay	-	-	-	8.6	2.3	41.0	6.0	30.1	Morrison (1946)
Red-top hay	-	-	-	7.3	2.2	44.0	8.0	29.6	Morrison (1946)
Bunchgrass hay	-	-	-	5.8	2.0	44.1	9.4	30.4	Morrison (1946)
Bunchgrass, misc.	-	-	-	4.3	1.2	23.9	4.2	15.8	Morrison (1946)
Phleum pratense	July 27	Wyoming	5.96	6.75	1.82	43.16	6.46	35.85	Knight (1906) from McCreary (1931)
Agropyron spicatum	Winter	Utah	-	2.92	2.32	44.58	9.62	40.57	Cook and Harris (1950)
Carex festivella	Aug. 2	Yellowstone or Jackson Hole	5.39	12.24	2.42	47.37	4.58	28.0	McCreary (1931)
Carex nebraskensis	July 29	Wyoming	6.42	9.0	2.54	44.65	7.83	29.59	Knight (1906) from McCreary (1931)

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